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FLOOD INSURANCE STUDY

ORIGINAL

COMPLETED

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CITY OF BRIDGE CITY, TEXAS
ORANGE COUNTY

JULY 6, 1982

Federal Emergency Management Agency

COMMUNITY NUMBER 480511

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map

FLOOD INSURANCE STUDY
CITY OF BRIDGE CITY, TEXAS

1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Bridge City, Orange County, Texas, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study will be used to convert the City of Bridge City to the regular program of flood insurance by the Federal Emergency Management Agency (FEMA). Local and regional planners will use this study in their efforts to promote sound flood plain management.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than those on which these Federally-supported studies are based. These criteria take precedence over the minimum Federal criteria for purposes of regulating development in the flood plain, as set forth in the Code of Federal Regulations at 44 CFR, 60.3 (d). In such cases, however, it shall be understood that the state (or other jurisdictional agency) shall be able to explain these requirements and criteria.

1.2 Authority and Acknowledgments

The source of authority for this Flood Insurance Study is the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by Tetra Tech, Inc. for the Federal Emergency Management Agency, under Contract No. H-4788. This study was completed in May 1980.

1.3 Coordination

The following organizations were contacted for coordination in the development of this study:

City of Bridge City
County of Orange
Bridge City Chamber of Commerce
National Oceanic and Atmospheric Administration (NOAA)
Rady and Associates, Inc.
Sabine River Authority of Texas
C. P. Smith Associates, Inc.
Southeast Texas Regional Planning Commission
Texas Highway Department
Texas State Department of Water Resources
U.S. Army Corps of Engineers (COE), Galveston District
U.S. Geological Survey (USGS)
U.S. Soil Conservation Service (SCS)

The State Coordinator was involved with this study through the Dallas Regional Office of the Federal Emergency Management Agency.

On February 11, 1982, the results of this study were reviewed at a final meeting attended by representatives of Tetra Tech, Inc., the City of Bridge City and FEMA. All changes resulting from that meeting have been included in this report.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the area of the City of Bridge City, Orange County, Texas. The area of study is shown on the Vicinity Map (Figure 1).

The study analysis includes coastline flooding due to hurricane-induced storm surge. Both the open coast surge and its inland propagation were studied; in addition, the added effects of wave heights were also considered. Flooding caused by the overflow of Cow Bayou was also studied in detail.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction for the next five years, through May 1985. The scope and methods of study were determined by FEMA, with the community and study contractor in consultation.

2.2 Community Description

The City of Bridge City is located in the southeastern portion of Texas in Orange County. It occupies an area of approximately 13.3 square miles just north of Sabine Lake. It is surrounded by unincorporated areas of Orange County. The city is located approximately 20 miles east of Beaumont and 5 miles southwest of Orange.

The U.S. Bureau of the Census recorded the 1970 population of Bridge City at 8,164 which represented a 74.6 percent increase over the 1960 census of 4,677 (Reference 1). The current population is estimated to be about 10,300, and represents an increase of approximately 26 percent over the 1970 level. It is estimated that the population of Bridge City will reach approximately 11,300 by 1985 (Reference 2).

Bridge City was incorporated in 1970 and is primarily urban. Its major commercial developments are generally located along U.S. Highway 87. Leading industries in the area produce steel, rubber, petrochemical products, ships and concrete. Agricultural products such as timber, rice, and soy beans also contribute to the economy of the area.

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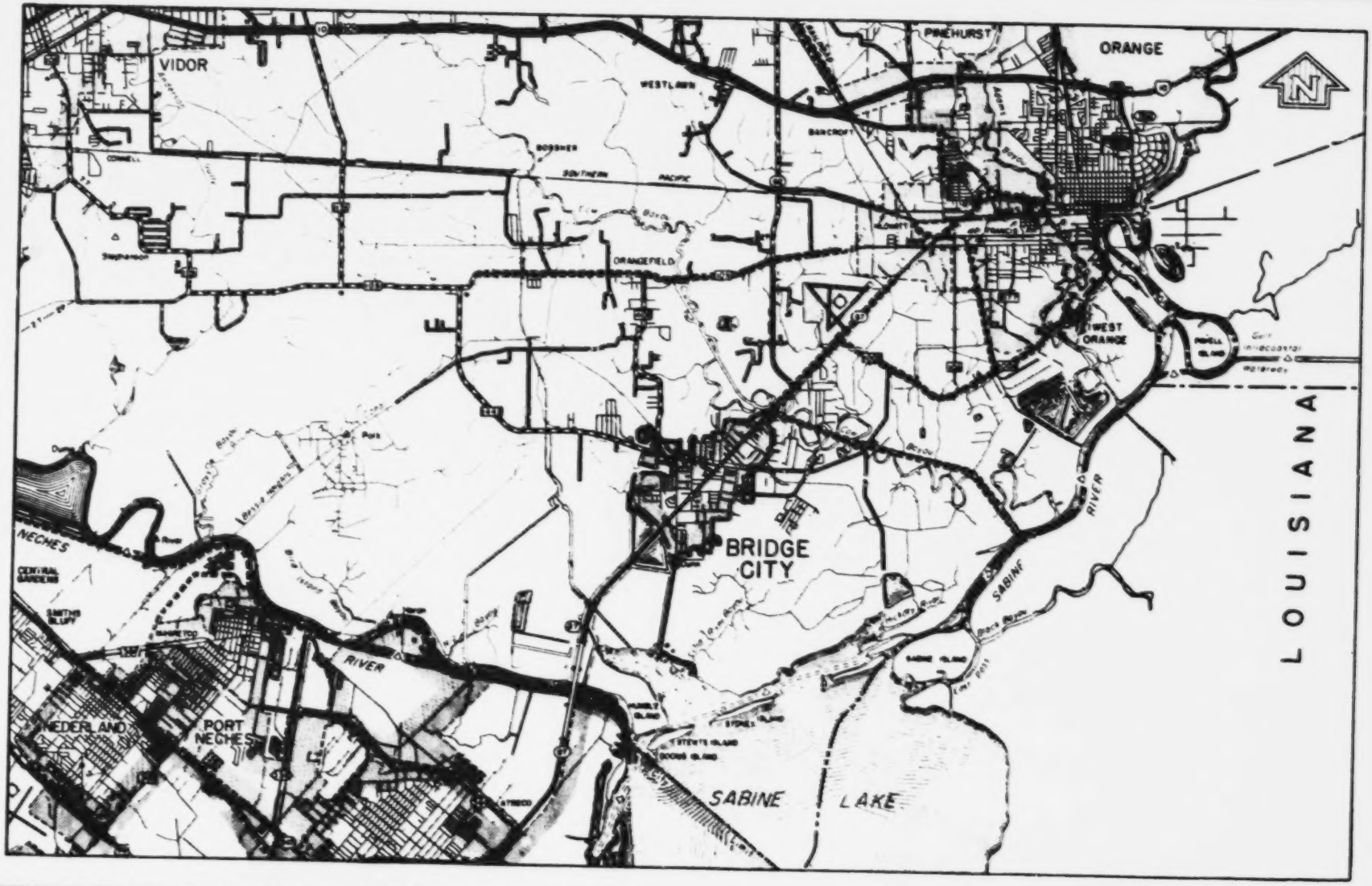

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX

(ORANGE CO.)

APPROXIMATE SCALE

0 1 2 3 4 5 6 7 8 9 MILES

VICINITY MAP

Bridge City is located in a humid subtropical climatic zone, which is characterized by moderate winters and warm summers. Rainfall is abundant, and, on the average, evenly distributed throughout the year. The Bridge City area is subject to intense local thundershowers of short duration during the summer months, and general storms which are more frequent in wintertime and extend over a period of several days. Hurricanes and other tropical disturbances usually occur between June and October, and are generally accompanied by torrential rainfall. The average annual precipitation is approximately 59 inches and the average annual temperature is approximately 68 degrees F (Reference 3).

Soils in Orange County are clayey and loamy that have moderate to low infiltration rates, and produce a moderate to high runoff potential. The soils are classified into SCS Groups A, B, C, and D for hydrologic purposes (Reference 4).

Physiographically, Bridge City lies in the transition zone between the Gulf Coastal Plain and the East Texas Pineywoods, on the watershed divide separating the Neches and Sabine Rivers. The terrain is relatively flat; its elevations are relatively low and range from about 5 to about 10 feet above National Geodetic Vertical Datum of 1929 (NGVD). Substantial areas are less than 10 feet NGVD. Since about 1975, some Orange County areas have undergone minor subsidence due to continued groundwater withdrawal and the inelastic behavior of the clay underlying those areas. The magnitude of the subsidence has been less than one foot (Reference 5).

The major stream within the study area is Cow Bayou. The Sabine River is to the east and the Neches River is to the southwest of the study area. Since the city is located on the watershed divide between these two rivers, it is subject to only minimal flooding from them. Cow Bayou flows southward from Jasper County through the northeastern corner of Bridge City, and empties into the Sabine River at the swamp east of Bridge City. It drains about 174 square miles of mostly forested and undeveloped land. The rate of runoff in the Bridge City area is generally slow because of the small conveyance capacities of the natural channel along Cow Bayou. These small capacities cause floods to frequently exceed bankfull stages for long periods of time.

2.3 Principal Flood Problems

Flooding in Bridge City results primarily from overflow of Cow Bayou (caused by rainfall runoff, ponding and sheet flow), and from tidal surges through the Bayou and Sabine Lake (caused by hurricanes and tropical storms). Because of the flatness of the terrain, many inland areas are characterized by shallow flooding during heavy rainfalls. Not all storms that pass close to the study area produce estremely high tides. Similarly, storms that produce extreme conditions in one area may not necessarily produce critical conditions in other locations. Cow Bayou is estuarine, and under certain conditions high tidal levels generated at its mouth in Sabine River can propagate far upstream. Rainfall, which usually accompanies hurricanes, can also aggravate tidal flood situations.

Storms passing Texas in the vicinity of Bridge City have produced severe floods as well as structural damage in the area. Although little information is known on past flooding in Bridge City itself, brief descriptions of several significant tropical storms can provide historic information to which flood hazards and the projected flood depths can be compared (References 6, 7, 8, 9, 10, 11, and 12).

April to June 1953

Heavy rainfall, produced by two storms, followed a period of above normal rainfall that had greatly built up the moisture content of the soil. Rainfall from April 28 to May 5 was more than 11 inches in the Lower Sabine and Neches River basins.

From May 13 to May 19, rainfall in nearby Orange was 11.91 inches. The storms caused extensive flooding in the lower areas -- homes were flooded, buildings damaged, roads inundated. There was minor flooding in downtown Orange on Water Street. The estimated velocities in the Sabine channel in the vicinity of Orange ranged up to 5 feet per second (fps); overbank velocities were lower (0.5 fps). The staff gage at Gulf State Utilities Pier read 6.0 feet NGVD on May 24. Flood damage to the area was estimated at $460,000.

September 21 to 23, 1958

This storm left 10.05 inches of rain in 24 hours, and 18.5 inches in 2 days. (Unofficial records show 14 inches in 9 hours at Orange.) A privately maintained gage at Bridge City recorded 14.75 inches on September 21 and a 2-day total of 18.5 inches of rainfall.

September 9 to 12, 1961 (Hurricane Carla)

This hurricane was accompanied by heavy rains and caused extremely high tides and crest stages of 6.6 feet NGVD on the Sabine River at the Gulf State Utilities staff gage at Orange (about the same elevation as the flood of 1913). There was flooding of homes situated in areas less than about 7 feet NGVD along Cow Bayou in Bridge City, where water rose to approximately 6.7 feet NGVD.

September 17 to 28, 1963 (Hurricane Cindy)

This hurricane, which made landfall at High Island, brought 15.8 inches of rain in 24 hours. The Gulf State Utilities staff gage on the Sabine River reached 4.4 feet on September 18. Damages were estimated at $249,000. The peak discharge (maximum runoff) produced on Cow Bayou near Mauriceville was 4,600 cfs. The torrential rainfall caused flooding and millions of dollars of damage to the Sabine-Neches area.

October 27-28, 1970

The Cow Bayou gage near Mauriceville indicated a peak discharge of 4,420 cfs.

April 19 to 24, 1979

Rainfall during this storm was recorded at more than 7 inches in Orange County, and caused flooding in many areas along the Neches and Sabine Rivers, and Adams, Cow and Little Cypress Bayous. Most severely affected was the Lakeview area in the northwestern section of the county, where approximately 200 dwellings were damaged. The Neches River crested at 11 feet (7 feet above flood stage), and the Sabine River crested at 1.3 feet above flood stage. Highwater was reported in the south Bridge City area.

July 25, 1979 (Tropical Storm Claudette)

Rainfall in Bridge City was estimated at 16 inches in 48 hours. The area around Ferry Drive and West Round Bunch Road was flooded when Cow Bayou overflowed its banks. The southeast addition to the southeast of Bridge City was also flooded. Texas Highway 87 between Bridge City and Rainbow Bridge was under water.

2.4 Flood Protection Measures

The Cow Bayou channel was enlarged by the COE in 1952 to a 13-foot depth and 100-foot width from its mouth to stream mile 7.0. The channel enlargement eased Cow Bayou from rainfall flooding but did not prevent surge intrusion.

Nonstructural flood protection measures in Bridge City consist of a flood hazard prevention ordinance adopted January 17, 1978. The ordinance places controls on the types of development and activities which are permissible in the flood plain. The National Weather Service provides forecasting and community flash flood warning services.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equalled or exceeded once on the average during any 10-, 50-, 100-, and 500-year period (recurrence intervals), have been selected as having special significance for flood plain management and for flood insurance premium rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equalled or exceeded during any year. Although the recurrence interval represents the long term, average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than one year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (one percent chance of annual occurrence) in any 50 year period is about 40 percent (four in 10), and for any 90 year period,

the risk increases to about 60 percent (six in 10). The analyses reported here reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish peak discharge-frequency relationships for floods of the selected recurrence intervals for each flooding source studied in detail in the community.

The determination of inundation from the Gulf of Mexico/Sabine Lake/Sabine River caused by passage of a hurricane storm surge was approached by the Joint Probability Method (Reference 13). The storm populations were described by probability distributions of five parameters that influence surge heights. These were central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle. These characteristics were described statistically based on an analysis of observed storms in the vicinity of Orange County, Texas. Primary sources of data for this were the National Weather Service (References 14, 15, and 16), the National Hurricane Research Project (Reference 17), and the Monthly Weather Review (Reference 18). A summary of parameters used for the Orange County area is presented in Table 1.

The determination of maximum wave crest elevations associated with the 10- and 100-year events was approached by the method recommended by the National Academy of Sciences (Reference 19). Further details are included in Section 3.3 of this study.

Flood magnitude and frequency for areas subject to flooding from the streams studied in detail were estimated using the COE HEC-1 Flood Hydrograph Package (Reference 20). Regionalized unit hydrograph and rainfall loss rate parameters were developed by hydrograph reconstitution studies using thirty storms in six gaged basins. The transposition of the HEC-1 model parameters from gaged to ungaged basins was based on hydrologic similarity, as assessed from soil maps (References 4 and 21), USGS topographic maps (Reference 22), recent air photos (Reference 23), and field reconnaissance. Urbanized watersheds were studied further using methodology developed by Beard (References 24 and 25). Rainfall data used to estimate flood discharges for the various frequency events were developed from hourly rainfall records from the National Climatic Center (Reference 26) and from TP-40 (Reference 27). The resulting "computations" storms used to generate peak discharges of selected frequency have depth-area-duration characteristics consistent with the Texas Gulf Coast area.

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CENTRAL PRESSURE DEPRESSION (Millibars)	5	15	25	35	45	55	65	75	85	95	105
PROBABILITY:											
ENTERING	19%	19%	19%	8%	11%	6%	7%	6%	2%	2%	1%
EXITING						N.A.					
PARALLEL						N.A.					
STORM RADIUS (Nautical Miles)			20					35			
PROBABILITY			75%					25%			
FORWARD SPEED (Knots)			8		14			20			
PROBABILITY:											
ENTERING			58%		31%			11%			
EXITING					N.A.						
PARALLEL					N.A.						
CROSSING ANGLE (Degrees)			-21		24			-69			
PROBABILITY			36%		30%			34%			
FREQUENCY OF OCCURRENCE	2.21×10^{-3} storms/nautical mile/year										

TABLE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX

(ORANGE CO.)

PARAMETER VALUES FOR SURGE ELEVATION COMPUTATIONS

The resulting estimated peak discharge for the selected frequencies for Cow Bayou is shown in Table 2, "Summary of Discharges." Also indicated in Table 2 is the drainage area.

TABLE 2 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
COW BAYOU					
At Roundbunch Road	165.0	7,700	10,800	12,500	15,700

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of the flooding sources studied in detail in the community were carried out to provide estimates of the elevations of floods of the selected recurrence intervals along each of the flood sources.

For areas subject to flooding directly from the Gulf of Mexico/Sabine Lake/ Sabine River, the Federal Emergency Management Agency's standard coastal surge model was used to simulate the coastal surge generated by any chosen storm (that is, any combination of the five storm parameters defined previously). Performing such simulations for a large number of storms, each of known total probability, permits one to establish the frequency distribution of surge height as a function of coastal location. These distributions incorporate the large-scale surge behavior but do not include an analysis of the added effects associated with much finer scale wave phenomena such as wave height, setup, or runup. The astronomic tide for the region is then statistically combined with the computed storm surge to yield recurrence intervals of total water level. The entire procedure is detailed in Reference 28.

The surge model employed in the procedure utilizes a grid pattern approximating the geographical features of the study area and the adjoining areas. Surges were computed using grid sizes of 5 nautical miles for open coast computations, and 1 nautical mile for Sabine Lake computations. The effects of the Sabine and Neches Rivers were included in the model. Surge levels in Cow Bayou were computed with the aid of a one-dimensional unsteady flow model. The surge values for the mouth of Cow Bayou were taken from the results in the coastal surge computations.

The computed stillwater flood elevations for Bridge City are tabulated in the Coastal Flood Insurance Zone Data Table (See Section 5.2).

Computations for flood levels along Cow Bayou resulting from either coastal surges or rainfall were independently performed. The results of each were combined statistically to obtain flood levels for each return period (Reference 28). In Bridge City, the results of the analysis show that surge flooding predominates rainfall flooding. Therefore, no stream profile is necessary. Refer to the Coastal Flood Insurance Zone Data Table for these flooding elevations.

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FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX
(ORANGE CO.)

FIGURE 2

TRANSECT LOCATION MAP

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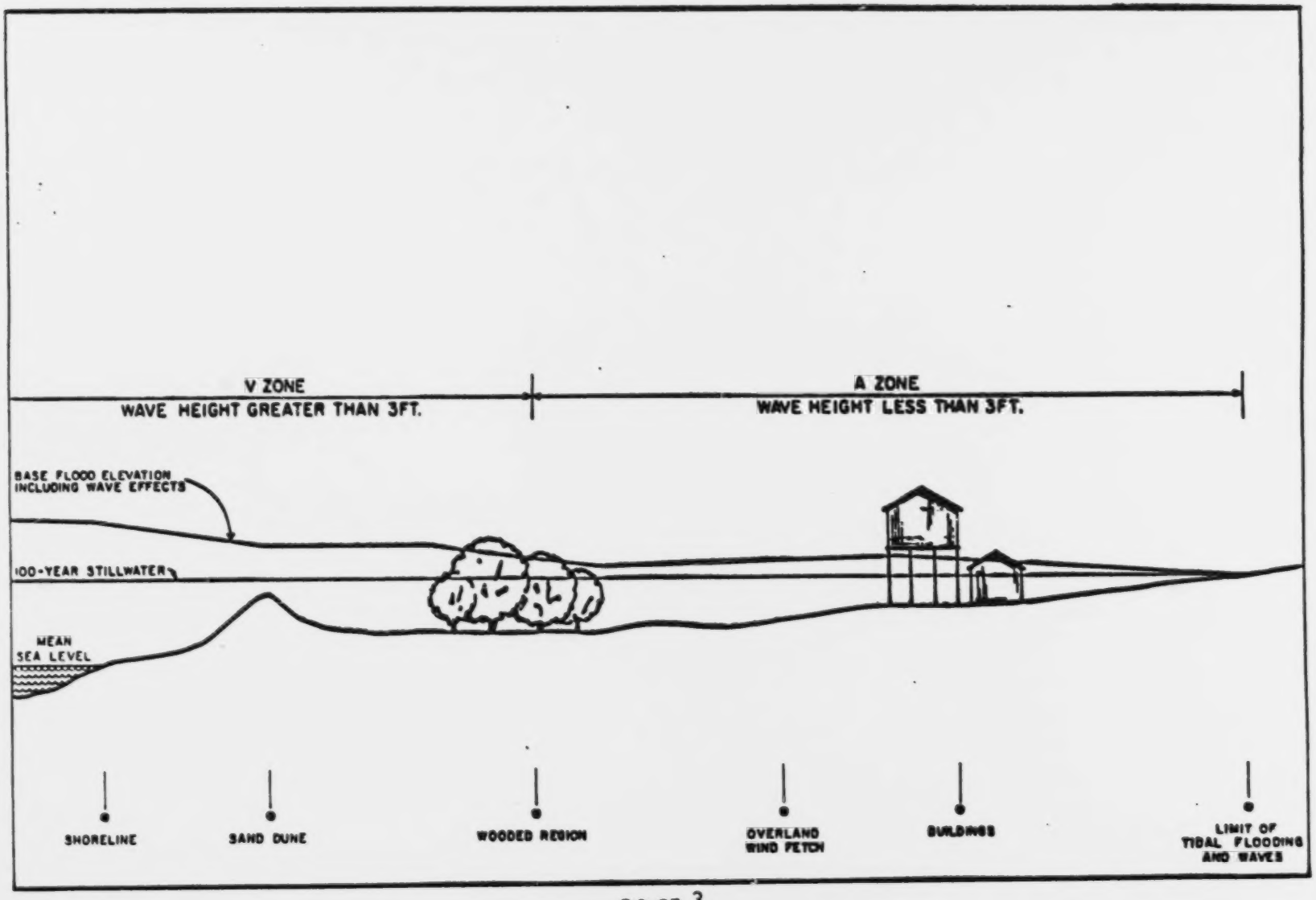

FIGURE 3
HYPOTHETICAL TRANSECT SCHEMATIC

3.3 Wave Height Analyses

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 19). This method is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest elevation is 70 percent of the total wave height plus the stillwater elevation. The second major concept is that wave height may be diminished due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in Reference 29. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

Wave heights were computed along transects (cross section lines) that were located along the coastal areas, as illustrated in Figure 1, in accordance with the Users Manual for Wave Height Analysis (Reference 29). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects.

The transects were continued inland until the wave was dissipated or until flooding from another source with equal or greater elevation was reached. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation and physical features. The stillwater elevations for the 100-year flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole-foot increments along the transects. Areas with a wave component 3-feet or greater were designated as velocity zones. Other areas subject to wave action were designated as A Zones with base flood elevations adjusted to include wave crest elevations.

Figure 3 is a profile for a hypothetical transect showing the effects of energy dissipation on a wave as it moves inland. This figure shows the wave elevations being diminished by obstructions, such as buildings, vegetation and rising ground elevations and being increased by open, unobstructed wind fetches. Actual wave conditions in the City of Bridge City may not necessarily include all the situations illustrated in Figure 3.

Figure 4 is a sample transect actually reflecting conditions in the community.

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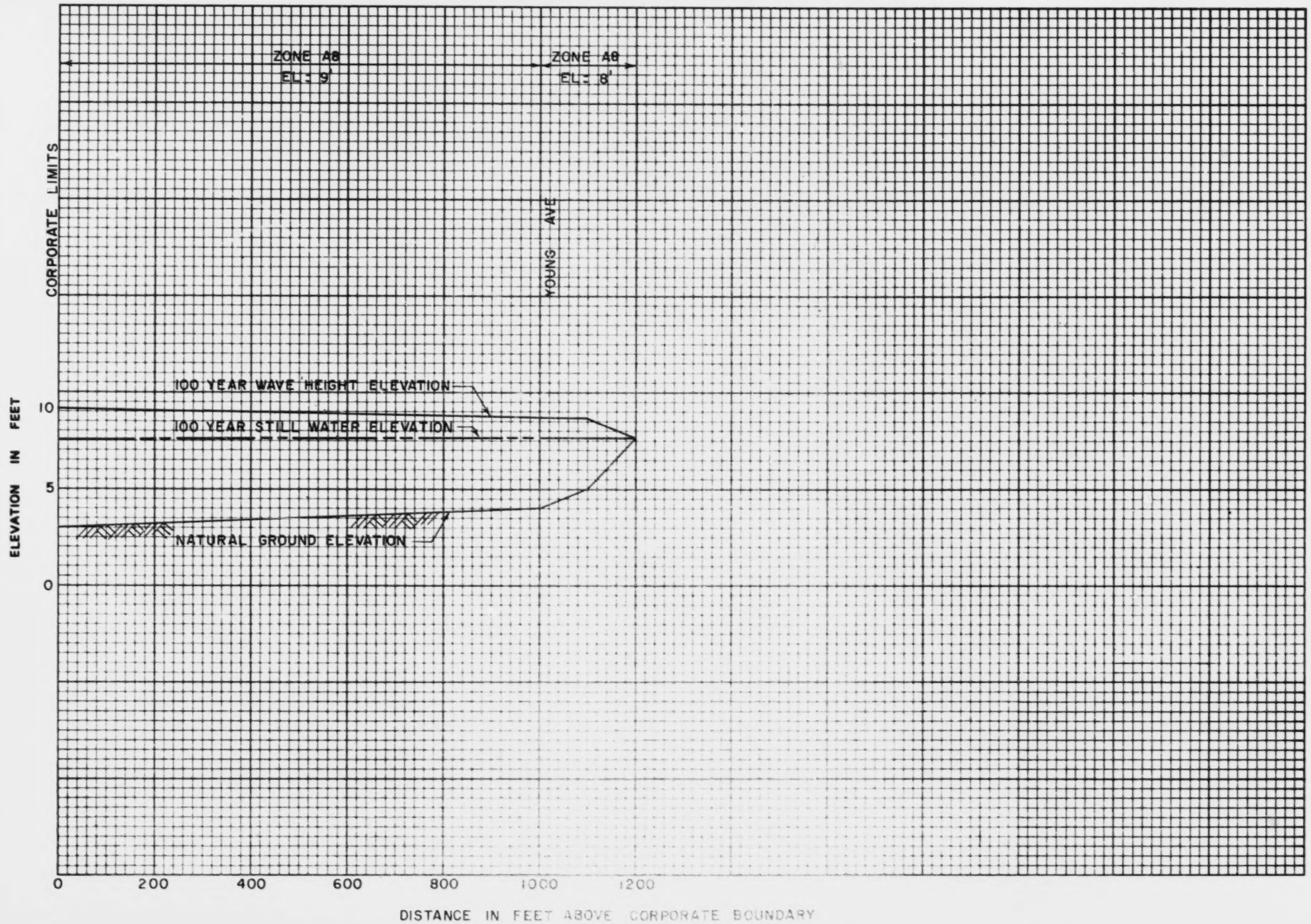

SAMPLE TRANSECT

TRANSECT I

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX
(ORANGE CO.)

FIGURE 4

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Cow Bayou Cross Section A	24,652	752[2]	5,311	2.4	7.6	5.4[3]	6.3[3]	0.9

[1]Feet above mouth
[2]Floodway extends beyond corporate limits
[3]Elevations computed without consideration of coastal flooding effects from Lake Sabine

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX

[ORANGE CO.]

FLOODWAY DATA

COW BAYOU

Data for the model grid systems and the wave height calculations were obtained from USGS topographic maps (Reference 22), National Oceanic and Atmospheric Administration nautical charts (References 30 through 34), and from aerial photographs (Reference 23). The results of this study are considered accurate until local topography, vegetation, or cultural development undergo any major changes.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown and described on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The National Flood Insurance Program encourages state and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study includes a flood boundary map designed to assist communities in developing sound flood plain management measures.

4.1 Flood Boundaries

In order to provide a national standard without regional discrimination, the 100-year flood has been adopted by the Federal Emergency Management Agency as the base flood for purposes of floodplain management measures. The 500-year flood is employed to indicate additional areas of flood risk in the community.

The boundaries of the 100- and the 500-year floods have been delineated using topographic maps at a scale of 1:24,000 with a contour interval of 5 feet (Reference 22), and aerial photographs at a scale of 1:9,600 ((Reference 23) as aids. Additional maps were consulted to cross check boundaries (Reference 35).

Flood boundaries are indicated on the Flood Insurance Rate Map. On this map, the 100-year flood boundary corresponds to the boundary of the areas of special flood hazards (Zone A8), and the 500-year flood boundary corresponds to the boundary of the areas of moderate flood hazards (Zone B). In cases where the 100- and 500-year flood boundaries are close together, only the 100-year flood boundary has been shown.

Small areas within the flood boundaries may lie above the flood elevations and, therefore, are not subject to flooding. Owing to limitations of the map scale, such areas are not shown.

4.2 Floodways

Encroachment on flood plains, such as artificial fill, reduces the flood-carrying capacity, increases the flood heights of streams, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, the concept of a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood is divided into a floodway and a floodway fringe. The floodway is the channel of a stream plus any adjacent flood plain areas that must be kept free of encroachment in order that the 100-year flood may be carried without substantial increases in flood heights. Minimum standards of FEMA limit such increases in flood heights to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this report are presented to local agencies as minimum standards that can be adopted or that can be used as a basis for additional studies.

Floodways are not delineated in coastal high hazard areas. The floodways proposed in this study for riverine areas were computed on the basis of equal conveyance reduction from each side of the flood plain. Floodway analyses were based on increasing the computed 100-year rainfall flooding level. The results of these computations are tabulated at a selected cross section for Cow Bayou (Table 3).

The surcharge identified in Figure 5 and tabulated in the last column of Table 3 represents the maximum 100-year water level increase that is permitted with encroachment. The tabulated values are the maximum increase in water level for the reaches studied such that the maximum water increase in areas considered anywhere upstream does not exceed one foot.

As shown on the Flood Boundary and Floodway Map (Exhibit 1), the floodway boundaries were determined at cross sections. Between cross sections, the boundaries were interpolated.

The area between the floodway and the boundary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 5.

4.3 Base Flood Elevations

Areas within the community studied by detailed engineering methods have base flood elevations established in A and V Zones. These are the elevations of the base (100-year) flood relative to the National Geodetic Vertical Datum (Mean Sea Level of 1929). In coastal areas affected by wave action, base flood elevations are generally maximum at the normal open shoreline. These elevations generally decrease in a landward direction at a rate dependent on the presence of obstructions capable of dissipating the wave energy. Where possible, changes in base flood elevations have been shown in 1-foot increments on the FIRMs. However, where the scale did not permit, 2- or 3-foot increments were sometimes used. Base flood elevations shown in the wave action areas represent the average elevation within the zone. These elevations vary from 7 to 9 feet above NGVD in the incorporated area of Bridge City and are shown on the Flood Insurance Rate Map. Current program regulations generally require that all new construction be elevated such that the first floor, including basement, is above the base flood elevation in A and V Zones.

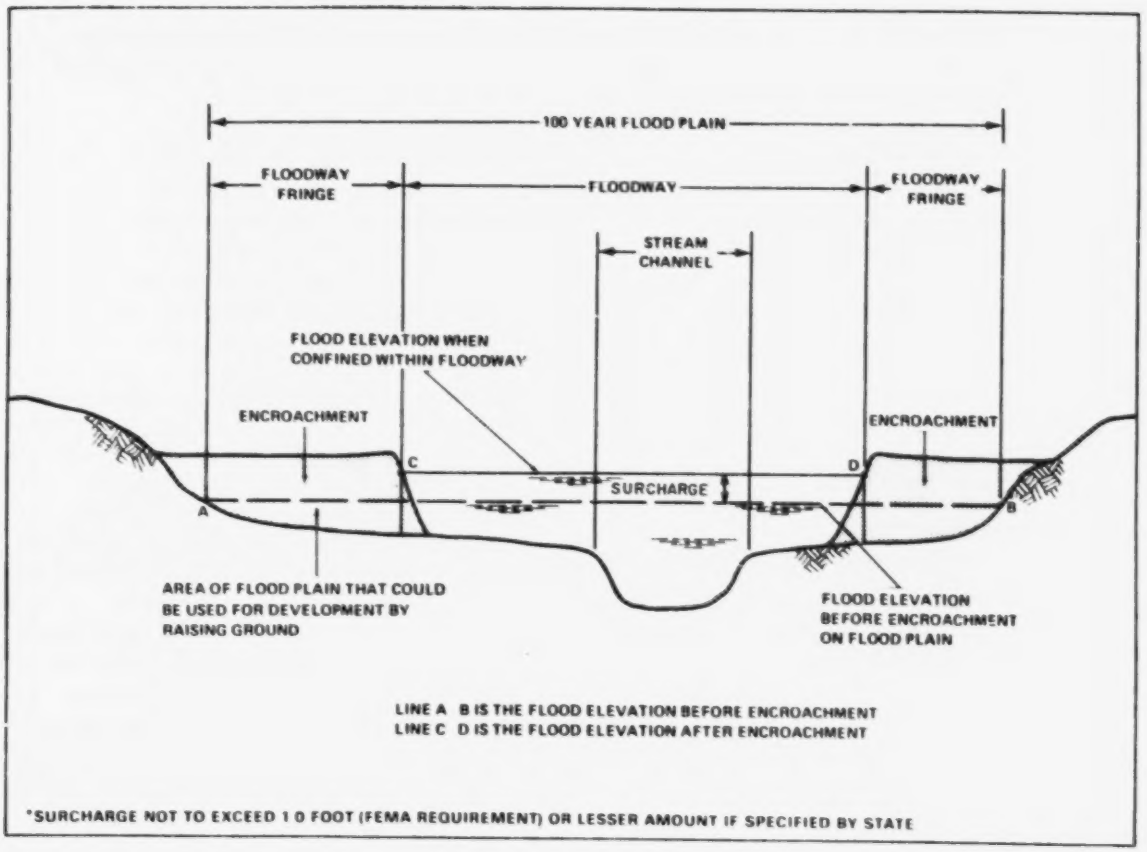
4.4 Velocity Zones

The U.S. Army Corps of Engineers (Reference 36) has established the 3-foot wave as the criterion for identifying coastal high hazard zones. This was based on a study of wave action effects on structures. This criterion has been adopted by the Federal Emergency Management Agency for the determination of V Zones. Because of the additional hazards associated with high-energy waves, the National Flood Insurance Program regulations require much more stringent flood plain management measures in these areas, such as elevating structures on piles or piers. In addition, insurance rates in V Zones are higher than those in A Zones with similar numerical designations.

The location of the V Zone is determined by the 3-foot wave as discussed previously. The detailed analysis of wave heights performed in this study allowed a much more accurate location of the V Zone to be established. The V Zone generally extends inland to the point where the 100-year flood depth is insufficient to support a 3-foot wave.

As shown on the Flood Boundary and Floodway Map (Exhibit 1), the floodway boundaries were determined at cross sections. Between cross sections, the boundaries were interpolated.

The area between the floodway and the bounary of the 100-year flood is termed the floodway fringe. The floodway fringe thus encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 5.


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

FLOODWAY SCHEMATIC Figure 5

5.0 INSURANCE APPLICATION

In order to establish actuarial insurance rates, FEMA has developed a process to transform the data from the engineering study into flood insurance criteria. This process includes the determination of Flood Hazard Factors (FHFs), and flood insurance zone designations for each significant flooding source affecting the City of Bridge City.

5.1 Flood Hazard Factors (FHFs)

Coastal flood plains are divided into areas having relatively the same flood hazard based upon the 100-year wave height and the average weighted difference in water-surface elevations between the 10-year and 100-year floods. These flood hazard areas are shown on the Flood Insurance Rate Map.

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The Flood Hazard Factor is used to correlate flood information with insurance rate tables. Correlations between property damages from floods and their assigned FHFs are used to set actuarial insurance premium rate tables based on FHFs from 005 to 200.

In coastal areas subject to wave action (wave heights greater than 3 feet), the FHF is determined using the difference between the 10-year and 100-year wave crest elevations. This difference is estimated as the difference between the 10- and 100-year stillwater elevations multiplied by 1.55. For areas where wave heights are less than three feet, the FHF is determined using the difference between the 10-year stillwater elevation and the 100-year wave crest elevation. For areas protected from wave action, the FHF is determined using the difference between the 10-year and 100-year stillwater elevations.

5.2 Flood Insurance Zones

After the determination of zones and their respective FHFs, the entire incorporated area of the City of Bridge City was divided into zones, each having a specific flood potential or hazard. Each zone was assigned one of the following flood insurance zone designations.

Zone A8:	Special Flood Hazard Areas inundated by the 100-year flood, determined by detailed methods; base flood elevations shown, and zones subdivided according to FHFs.
Zone B:	Areas between the Special Flood Hazard Area and the limits of the 500-year flood, including areas of the 500-year flood plain that are protected from the 100-year flood by dike, levee, or other water control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; or areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flooding.

Table 4, "Coastal Flood Insurance Zone Data," summarizes the stillwater flood elevations, FHFs, flood insurance zones, and base flood elevations by transect for each flooding source studied in detail in the community.

FLOODING SOURCE	TRANSECTS	PANELS	STILLWATER ELEVATIONS				FLOOD HAZARD FACTOR[1]	ZONE[1]	BASE FLOOD ELEVATION[2] (FEET NGVD)
			10-YR	50-YR	100-YR	500-YR			
Gulf of Mexico/ Sabine Lake	1	0005	3.8	6.3	7.3	9.5	040	A8[3]	7
	2	0005	4.2	6.7	7.6	9.7	040	A8[3]	8-9
	3	0005	4.4	6.9	8.0	10.4	040	A8	8
	4	0005	4.0	6.7	7.6	9.7	040	A8	8

1-Includes the effects of Wave Action, where applicable.

2-Due to map scale limitations, Base Flood Elevations (BFEs) shown on the Flood Insurance Rate Map may represent average elevation for the zone depicted.

[3]Average Weighted Value

TABLE 4

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BRIDGE CITY, TX

(ORANGE CO.)

COASTAL FLOOD INSURANCE ZONE DATA

GULF OF MEXICO/SABINE LAKE

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5.3 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Bridge City is, for insurance purposes, the principal result of the Flood Insurance Study. This map (published separately) contains the official delineation of flood insurance zones and base flood elevation lines. Base flood elevation lines show the locations of the expected whole-foot water-surface elevations of the base (100-year) flood. This map is developed in accordance with the latest flood insurance map preparation guidelines published by FEMA.

6.0 OTHER STUDIES

A Flood Insurance Study for the City of Bridge City (Reference 6) was prepared by the COE, Galveston District, in 1977. Other flood-related studies which concentrate on portions of the study area include a Flood Insurance Study for Orange County (Reference 37), Flood Insurance Studies for the area from Sabine Lake to Matagorda Bay (Reference 38), Flood Insurance Studies for the Cities of Orange and West Orange (Reference 7), and Pinehurst (Reference 39); a Flood Plain Information Study that covers Sabine River and Adams Bayou (Reference 9); a comprehensive basin study on the Sabine River (Reference 40); the National Shoreline Study (Reference 41) and Texas Coast Hurricane Study (Reference 10) by the COE, Galveston District; 100-year hurricane surge elevations for the gulf of Mexico/Sabine River published in the Flood Insurance Studies for neighboring Jefferson County, Texas and Cameron and Calcasieu Parishes, Louisiana (Reference 42, 43, and 44); and the Hurricane Surge Frequency Study by the U.S. COE, Coastal Engineering Research Center (Reference 45). A number of other information sources were used for background purposes.

Some of the previously published 100-year surge elevations are higher than those in this report, some are lower. The differences are the result of different engineering methodologies and judgements. The present study adopted more detailed methods than used in the past for the hydraulic, hydrologic, coastal engineering, and statistical aspects of the work.

This study is authoritative for the purposes of the National Flood Insurance Program, and data presented in this report either supersede, or are compatible with all previous determinations.

7.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting the Natural and Technological Hazards, Federal Emergency Management Agency, Federal Center, Denton, Texas 76201.

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